The Formation and Evolution of Massive Young Star Clusters
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Properties of the ionizing clusters of HII galaxies as derived from photoionization models

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Abstract. HII galaxies are objects nowadays in the *eye of the hurricane* mostly due to the questions still open about their evolutionary status. This work is a continuation of a study of the chemical properties and ionization structure of a set of 12 HII galaxies observed in the optical and near IR part of the spectrum. In the present work we make use of the Wolf-Rayet features observed in a subsample of seven of them and apply photoionization models to derive the properties of the massive ionizing star clusters – age, mass, metallicity, etc ... – and check on the consistency with the gas properties derived in our previous work.

Blue Compact Galaxies (BCGs) are objects in which we can find some of the most violent star formation processes in the local Universe. Their properties, such as their compact aspect, low surface brightness, very blue colors, HII region-like spectra and very low metallicities make them, as well, very suitable to study some interesting questions about their evolutionary link with primeval galaxies, star formation triggering factors or their actual metallicity. In a previous work (Pérez-Montero & Díaz 2003), we observed the 7000 Å-1μ spectral range in a sample of 12 HII galaxies, that complete the blue-visual range in order to understand much better the inner ionization structure and the determinations of the chemical abundances of the ionized gas.

We have now improved the single star photoionization models presented in that work using Cloudy96 including the most recent synthetic cluster atmospheres (Smith et al. 2002) as implemented in Starburst99 in order to find out to what extent this more realistic scheme improves the determination of the chemical properties of the gas in relation with our previous models. All models use a Salpeter IMF with theoretical wind models at the metallicity measured in the gas. As well, the comparison with some observable properties of the spectrum, such as the Wolf-Rayet (WR) features observed by Guseva et al. (2000) in a subsample of seven of the objects allow us to give some constraints to the nature of the ionizing star clusters. Input to the models are: the deduced chemical abundances and electron density, and the observed Hβ equivalent widths (EW(Hβ)), Hα fluxes and a plane-parallel geometry of the gas assumed to be located at a radius equal to that observed in the Hα photometry (Gil de Paz et al. 2003).

In all cases we require a very young cluster with less than 2 Myr to obtain the ionization parameter (*i.e.* the ratio of ionizing photons and the hydrogen particles) necessary to fit the observed ratio of the nebular emission lines of [OII] and [OIII] to Hβ. This population, moreover, governs the ionization structure of the nebula. Nevertheless, the observed EW(Hβ) for all the objects is lower

Table 1. Metallicity, age and mass of the ionizing clusters of the objects of our sample from the best fitted models.

Object	12+log(O/H)	**Age y.c.** (Myr)	**Mass y.c.** (10^6 $M_\odot$)	**Age o.c.** (Myr)	**Mass o.c.** (10^6 $M_\odot$)
II Zw 40	8.07±0.02	1.5	1.55	3.2	1.05
		1.5	1.88	4.1	1.04
Mrk 5	8.01±0.05	0.5	0.11	4.0	0.02
SBS 0926+606	7.97±0.04	0.5	0.80	4.1	1.82
		0.5	1.06	5.0	1.68
Mrk 22	8.02±0.06	1.5	0.31	4.2	0.57
Mrk 1434	7.83±0.04	2.0	0.28	4.5	0.96
UM 462	7.97±0.04	1.5	0.25	4.0	2.46
		1.5	0.86	5.0	2.46
Mrk 209	7.88±0.02	1.5	0.05	3.2	0.05
		1.5	0.07	4.1	0.04

than the value predicted by the models at this very young age. Besides, the observation of WR features in the spectra of the galaxies points to the existence of an additional population with an age between 3 and 5 Myr. Using the same method as Castellanos et al. (2002), we can use WR features to estimate the age of the older population in combination with the very young one. The results of the ages and the masses of both populations in the best models for the entire sample is shown in Table 1. Contrary to Raimann et al. (1999), whose analysis is based on several indicators of the spectra of compact galaxies, we find that for all objects the masses of both populations are quite similar.

Regarding the length of the star formation processes the synthetic atmospheres only provide spectral energy distributions for both instantaneous burst and continuous star formation. We have used the first one because the second possibility gives very large EW(Hβ) for the models reproducing the observed WR features. The most probable scenario, a combination of two bursts of finite length, is not available.

In two objects of the sample (IIZw40 and Mrk5), the observed WR feature in the 4650 Å (*blue bump*) is larger than in the model. This could be due to an underestimate of the chemical abundance (perhaps due to temperature fluctuations), but for the rest of the sample, the calculated oxygen abundances agree quite well with the models and even for one object of the sample (UM461) a cluster with a metallicity lower than that of the enriched gas is compatible with the observations.

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